ENERGY ENGINEERING ANALYSIS
LIVORNO MILITARY COMMUNITY

Volume I

Executive Summary

PREFINAL

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FINAL REPORT

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Energy Engineering Analysis Program in Europe

Livorno Military Community

Volume I

Executive Summary

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I. INTRODUCTION

A. General

- This EEAP study was performed on three installations on USMCA Livorno: Camp Darby, Darby Depot, and Coltano.
- It analyzes the energy consumption patterns of calendar year 1980 and makes several recommendations concerning operations and energy use.
- The field work commenced in January 1981 and was completed in July of that year.
- The analysis made extensive use of BLAST and other energy analysis techniques including:
  1) European energy price forecasts,
  2) Weather tape transcription programs, and
  3) Retention risk analysis.
- Significant energy wastes have been located on USMCA Livorno.
- A comprehensive energy management plan has been developed to save both energy and funds for USMCA Livorno.
- Projects under way in 1981 will achieve annual savings of 23.7×10^9 Btu and $182,000.

B. Results

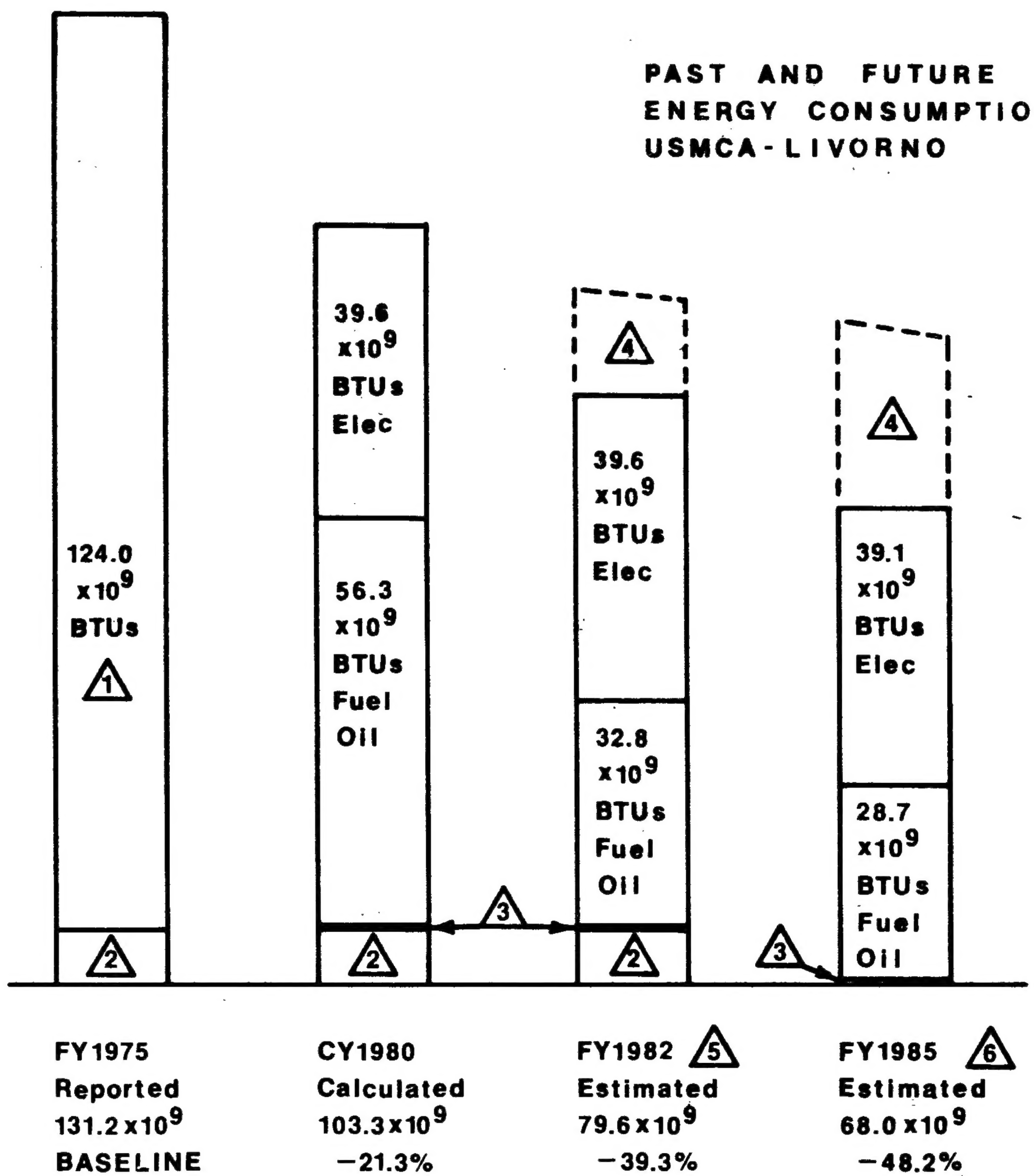
- Recommended projects will achieve annual savings of 11.6×10^9 Btu and $349,500 by 1986.
- Energy consumption will fall by 48.1% of 1975 levels.
- Expenditures will fall by 29.1% of 1980 levels in real dollars.
- Funded projects have an estimate total cost of $1,780,000 in 1981 dollars.

II. ENERGY CONSUMPTION

A. Historic and Forecasted Energy Consumption

- The three installations consumed 131.2×10^9 Btus in 1975.
- Records indicated this had fallen to 103.3×10^9 Btus in 1980, a savings of 21.3%

PAST AND FUTURE
ENERGY CONSUMPTION
USMCA-LIVORNO



NOTES:

1. 124.0×10^9 BTUs cannot be subdivided.
2. 7.2×10^9 BTUs Coltano emergency generator losses.
3. $.2 \times 10^9$ BTUs LPG.
4. Increase not part of 1975 baseline.
5. Includes savings from community-generated projects only.
6. Includes savings from projects recommended by EEAP report.

FIGURE I.1

- o Projects in work in 1981 should save an additional 23.7×10^9 Btu.
- o When recommended actions are complete, consumption should fall to 68.0×10^9 Btu on the study areas, a savings of 48.1%.

B. Energy Consumption by Energy Source

- o Calendar year 1980 (CY1980) energy consumption by source is shown below.

ENERGY CONSUMPTION BY SOURCE, CY1980
USMCA LIVORNO

Source	Amount	Energy	Cost
Electric Energy	11.6×10^6 kWhr	39.6×10^9 Btu	$ 542,700
Electric Demand	-----	-----	60,167
#2 Fuel Oil	435,300 gal.	56.2×10^9 Btu	373,150
LPG	-----	266×10^6 Btu	4,113
Diesel*	55,646 gal.	7.2×10^9 Btu	55,400
Totals		103.3×10^9 Btu	$1,035,500

* For emergency generators on Coltano.

C. Energy Consumption by Installation

- o Calendar year 1980 (CY1980) energy consumption by installation is shown below.
- o Area, Cost, Unit Energy Use, and Unit Energy Cost is also shown in below.

ENERGY CONSUMPTION BY INSTALLATION, CY1980
USMCA LIVORNO

Location	Area (ft^2)	Energy (10^9 Btu)	Unit Use (Btu/ft^2)	Cost * ($)	Unit Cost ($\$/ft^2$)
Camp Darby	462,478	60.9	131,700	520,800	1.13
Darby Depot	688,536	18.5	26,870	197,700	.29
Coltano	36,940	23.9	647,700	317,000	8.58

D. Distribution of Energy on Installations

Use	10^9 Btu	%
Camp Darby Space Heating	21.3	20.5
Camp Darby Domestic Hot Water	3.1	3.0
Camp Darby Heating Plant Losses	22.0	21.2
Camp Darby Building Electrical	13.6	13.1
Camp Darby Heating Plant Electrical	.2	.2
Camp Darby Perimeter and Street Lighting	.3	.3
Camp Darby Electrical System Losses	.2	.2
Camp Darby LPG	.2	.2
Darby Depot Space Heating	5.6	5.4
Darby Depot Heating Plant Losses	4.3	4.1
Darby Depot Building Electrical	8.1	7.8
Darby Depot Heating Plant Electrical	.2	.2
Darby Depot Perimeter and Street Lighting	.2	.2
Darby Depot Electrical System Losses	.1	.1
Darby Depot LPG	.5	.5
Coltano Communication Equipment	7.6	7.3
Coltano Diesel Generator Losses	7.2	6.9
Coltano Mission-Sensitive Air Conditioning	3.6	3.5
Coltano UPS Losses	3.1	3.0
Coltano Perimeter Lighting	1.4	1.3
Coltano Other Loads	1.0	1.0
	103.8	100.0

E. Typical Building Energy Consumption

- All buildings on the study installations were assigned to one of eight building types. Descriptions, energy parameters, and input data for BLAST ZONE models for each of these types can be found in Volume III.
- "Average" buildings of each type were constructed from audit data using hand calculating techniques. The year-round energy consumption characteristics of each "average" building was ascertained using annual BLAST runs and a weather tape.
- These "average" constructions were used to model present and future energy consumption of the community.

III. ENERGY CONSERVATION OPPORTUNITIES (ECO'S) ASSESSED

A. Operational and Maintenance ECO's

OM-1	Control Infiltration
OM-2	Consolidate Services into Permanent Buildings
OM-3	Reschedule Use of Facilities
OM-4	Reset Temperature Controls
OM-5	Reduce Heating and Cooling in Little-Used Areas
OM-6	Manage Domestic Hot Water More Efficiently
OM-7	Operate HVAC Systems More Efficiently
OM-8	Operate Heating and Cooling Plants More Efficiently
OM-9	Manage Electrical and Lighting Systems More Efficiently
OM-10	Operate Waste Treatment Plants More Efficiently
OM-11	Operate Distribution Systems More Efficiently

B. Funded ECO's

F-1	Weatherstrip Doors and Windows
F-2	Add Vestibules
F-3	Insulate Building Structures
F-4	Install Double-Pane Insulating Glass
F-5	Upgrade Domestic Hot Water Systems
F-6	Upgrade HVAC Systems
F-7	Upgrade Heating Plants
F-8	Upgrade Electrical and Lighting Systems
F-9	Upgrade Waste Treatment Systems
F-10	Upgrade Heating Distribution Systems
F-11	Add Heat-Recovery Systems
F-12	Install EMCS
F-13	Add Temperature Control Systems
F-14	Interconnect Existing Power Plants
F-15	Consolidate Heating Plants
F-16	Connect to Commercial Heating Systems
F-17	Sell Steam to Local Communities
F-18	Recover Energy from Waste

F-19 Install Solar Systems

F-20 Use Renewable Energy Sources

F-21 Exploit Passive Techniques

C. ECIP Parameters of Common Projects

Project	Cost ($\$10^3$)	Savings (10^6 Btu)	Benefit ($\$10^3$)	B/C(*)	E/C(*)	Payback (years)
Vestibules for high traffic entries	40	1	.05	--	.03	6,115
Double-pane windows for barracks	561	800	24.4	.04	1.4	150
Heat recovery for wash rack	55	1	.05	--	.02	7,170
Aluminum roofs	55	3	.15	--	.05	2,400
Rewire building, add new lights	15	2	.10	--	.13	1,020
New street lights	86	12	.57	--	.14	972
Exhaust hoods	45	1	.05	--	.02	6,115
Rewire hospital	260	2	.10	--	--	17,670
Insulate type III building	300	500	25	.08	1.7	78
Replace air conditioning unit	180	2	.10	--	.01	12,300
Repair switchgear	10	10	.47	.05	1.0	136

* Values less than .01 have not been entered.

D. ECIP Parameters of Other Projects Assessed

Project	Cost ($\$10^3$)	Savings (10^6 Btu)	Benefit ($\$10^3$)	B/C	E/C	Payback (years)
Power factor correction (same penalty level)	25	0	8.3	.33	(1)	19.7
Power factor correction (penalty level .9)	25	0	163	6.5	(1)	1.0
Weatherstripping (one window)	.08	.25	.02	.25	3.1	21.3
LPS streetlights (single pole)	.375	3.3	.10	.27	8.8	25
Load shedding	370	0	3.4	.09	(1)	111
EMCS						
Solar hot water for hypothetical barracks						
($900\ ft^2$ collector)	110	736	36.7	.33	6.7	19.5
($600\ ft^2$ collector)	80	589	29.3	.37	7.4	17.7
Solar hot water for bldg 696						
(80% system)	237	235	20.9	.09	1.0	74
(95% system)	307	235	20.9	.07	.8	96
Energy-saving fluorescent lights (per 1000 fixtures)						
replace lamps	2.38		12.24	5.1	(2)	(2)
change lamps	5.28		12.24	2.3	(2)	(2)
lamp & ballast	28.42		14.28	.5	(2)	(2)
change fixture	230.00		14.28	.06	(2)	(2)

(1) Values less than .01 have not been entered.

(2) Depends on time lit per year.

E. Additional Measures Assessed

- o Hospital building 113 HVAC.
- o Coltano HVAC.
- o Heating plant operation and maintenance.
- o Electric meters for tenant units.
- o Wood as a fuel.
- o The possible use of coal as a boiler fuel for Livorno.
- o Emergency generator operations on Coltano.
- o Uninterruptible Power Supply (UPS) for Coltano

IV. RECOMMENDED COMMUNITY ENERGY MANAGEMENT PLAN

A. Present Actions that Should Continue

1. Emphasis on conservation ethic.

2. Installation of new radiators featuring flow control valves and remote temperature sensors.

3. Replacement of damaged window units with double-pane.

B. Energy Conservation Modifications Made Since 1975

1. Timers and thermostatic mixing valves should reduce energy consumption by 10.7×10^9 Btu/yr.

C. Planned Facility Modifications

1. Incorporation of photocells: not recommended.

2. Separate electric meters: not recommended.

3. Heating plant maintenance: recommended.

4. New vestibules and replacement of sound windows: not recommended.

5. Replacement of burnt-out fluorescent lamps with energy-saving ones: recommended.

6. Replacing sound air conditioning systems: not recommended.

7. Replacing rotary UPS with solid state devices: recommended.

8. Planned maintenance: recommended.

D. Operational and Maintenance Energy Conservation Opportunities (Increment F)

1. The energy and dollar savings from recommended operating and maintenance actions are listed below.

Action	Energy Saved (Btu/yr)	Dollars Saved (total benefit)
Preventive Maintenance Program	--	$1,785,000
Curtailment of Standby Generators	7.21×10^9	357,500

E. Funded Energy Conservation Projects (Increments A, B, E, and G)

1. The funded ECOs assessed for Livorno are listed below.

Project	ICC ($\$10^3$)	Energy Saved (Btu/yr)	Cost Saved ($\$10^3$/yr)	B/C	E/C	Payback	Inc.	Rec
Boiler Consolidation	$2,492	2.3×10^9	$292	1.52	.923	4.3	E	Yes
Vestibule	40	1×10^6	.007	(1)	.03	6,115	G	No
Double-pane windows	561	$.8 \times 10^9$	3.8	.04	1.4	150	B	No
Rewire building	15	2×10^6	.03	(1)	.13	1,020	G	No
New streetlights	86	12×10^6	.09	(1)	.14	6,115	G	No
Insulate building	300	$.5 \times 10^9$	5.2	.08	1.7	78	B	No
Power factor correction								
(same penalty level)	25	0	1.3	.33	(1)	19.7	G	No
(.9 penalty level)	25	0	163	6.5	(1)	1.0	G	Yes
Weatherstripping	.08	$.25 \times 10^6$	.003	.25	3.1	21.3	G	No
LPS streetlights	.375	3.3×10^6	.015	.27	8.8	25	G	No
Load Shedding	370	0	.52	.09	(1)	111	B	No
EMCS							B	No
Solar hot water for hypothetical barracks								
(900 ft^2 collector)	110	736	5.65	.33	6.7	19.5	-	No
(600 ft^2 collector)	80	589	4.51	.37	7.4	17.7	-	No
Solar hot water for bldg 696								
(80% system)	237	235	3.2	.09	1.0	74	-	No
(95% system)	307	235	3.2	.07	.8	96	-	No
Energy-saving fluorescent lights (per 1000 fixtures)								
replace lamps	2.38	$.8 \times 10^9$	12.24	5.1	(2)	(2)	G	Yes
change lamps	5.28	$.8 \times 10^9$	12.24	2.3	(2)	(2)	G	No
lamp & ballast	28.42	$.95 \times 10^9$	14.28	.5	(2)	(2)	G	No
change fixture	230.00	$.95 \times 10^9$	14.28	.06	(2)	(2)	B	No

(1) Values below .01 have not been entered.

(2) Depends on time lit per year.

2. The recommended projects listed in descending B/C ratio order:

Project	ICC ($\$10^3$)	Energy (Btu/yr)	Cost ($\$10^3$/yr)	B/C	E/C	Payback
Power factor correction (.9 penalty level)	25	0	163	6.5	0	1.0
Energy-saving fluorescent lamps (per 1000 fixtures) replace lamp only	2.38	$.8 \times 10^9$	12.74	5.1	--	--
Boiler Consolidation	2,492	2.3×10^9	292	1.52	.92	4.3

(1) Depends on time lit per year

3. Increment G projects are listed in descending E/C ratio order:

Project	ICC ($\$10^3$)	Energy (Btu/yr)	Cost ($\$10^3$/yr)	B/C	E/C	Payback
LPS streetlights	.375	3.3×10^6	.015	.27	8.8	25
Weatherstripping	.08	$.25 \times 10^6$	.003	.27	3.1	21.3
New streetlights	86	12×10^6	.09	(1)	.14	6,115
Rewire building	15	2×10^6	.03	(1)	.13	1,020
Vestibule	40	1×10^6	.007	(1)	.03	6,115

(1) Less than .01

V. OTHER STUDY RESULTS

A. Energy Price Forecasts

- Spring 1981 study correctly forecast real decline of energy prices evident in 1981 and 1982.
- Same sources and methods predict real decline will continue throughout decade of the 1980s.
- Economic analyses reflect this current prediction and to that extent contradict earlier studies which may have merely extrapolated steep relative inflation of energy prices seen in 1979 and 1980.
- Projected unit energy costs are shown below.

PROJECTED UNIT ENERGY COSTS

Source	Unit Cost per 10^6 Btus in Jan 81	Jan 85	Jan 91
Electricity			
Camp Darby & Depot	$15.22	$18.26	$22.11
Coltano	15.69	18.82	22.80
#2 Oil	7.67	11.12	17.34
#5 Oil	4.69	6.80	10.60
LP Gas	15.45	22.39	34.93
Diesel Oil	7.67	11.12	17.34

B. Population and Occupancy Forecasts

- An analysis of variance (ANOVA) study of past USMCA Livorno population data using Student's t indicated no significant historical trend.
- Study assumes a 50% population increase through the 1980s.
- Actual troop strength is classified and unavailable for this study.
- For estimates of day- and nighttime populations of the three installations studied, see Appendix F-2 in Volume III.

C. BLAST

- Camp Darby and the Depot were analyzed with an innovative application of the BLAST program that enabled not only buildings but also the operation of heating plants to be modeled. This innovative analysis consists of six steps.
  1. Assigning all energy-using buildings into one of eight types. (See Appendix C-1 in Volume III for building classification.)
  2. Auditing a significant number of buildings in each type.
  3. Combining all audit data in each building type to produce an "average" building using hand calculation.
  4. Constructing a BLAST model for each "average" building as a ZONE.

5. Grouping proper numbers of properly-sized ZONES using the "zone multiplier" parameter of a SYSTEM to model the buildings served by each distribution system.
6. Applying heating system audit data to model all the heating plants on the 11 installations as PLANT models.

- The additions to the standard BLAST LIBRARY required to model USMCA Livorno's installations can be found in Appendix F-4 in Volume III.
- ZONE input data for each building type can be found in Appendix F-4.
- Input data required to model the operation of the heating plants on USMCA Livorno can be found in Appendix F-4.
- Characteristics for the seven different PLANT models necessary to analyze energy use on USMCA Livorno can be found in Appendix F-4.
- The accuracy of the resulting BLAST models are given below:

ACCURACY OF BLAST MODELING
USMCA LIVORNO

Installation	Calendar 1980 Consumption (10^9 Btu) Reported	Calendar 1980 Consumption (10^9 Btu) Calculated	Mismatch (%)
Camp Darby			
Fuel	46.6×10^9 Btu	46.3×10^9 Btu	.6
Electricity		4.2×10^6 kWhr	
Darby Depot			
Fuel Oil	9.9×10^9 Btu	9.9×10^9 Btu	0.0
Electricity		2.5×10^6 kWhr	
Total Electricity	6.3×10^6 kWhr	6.7×10^6 kWhr	6.3

D. Weather

- No suitable weather tape exists for northern Italy. The Verona tape only has entries for 0800 to 1600.
- Pisa airport weather summaries were obtained from the Italian Air Force Weather Service in Rome: "Frequenze e Medie delle Osservazioni Esquite nel Quindicennio 1951-65, Stazione Meterologica di Pisa"

- A Livorno weather tape was created from this data with the ADJUST program.
- Year-round daily weather summaries can be found in Appendix B-1.
- Day-long hourly weather summaries of the winter and summer design days can be found in Appendix B-1.

E. ADJUST (Weather Tape Construction Program)

- A program developed by the U.S. Bureau of Standards to construct weather tapes in an NBSLD format was modified to read and create 1440 format weather tapes.
- A Livorno tape was created using this program, Italian Air Force weather summaries for the Pisa airport, and a Sigonella weather tape provided by EUDAP-S.
- The FORTRAN code of the modified ADJUST program has been included in Appendix J-2 in Volume III.

F. Retention Risk

- The expected lifetime of existing energy-consuming equipment is critical in proper economic analysis of long-term projects.
- A combined statistical/econometric model of the risk attendent upon retaining such equipment was developed for this study.
- Based on actual lifetime data, the Weibull Distribution, and the Present Value Multiplier from the ECIP Guide, Retention Risk for various types of equipment can be calculated.
- Retention Risks for well-maintained oil-fired boilers and ill-maintained oil-fired boilers of current ages 1 through 30 years can be found in Appendix F-8 in Volume III.

G. ECIP Analysis in Italy

- Incremental Escalation Rates and Escalation Factors for Extending Costs and Benefits given in the 7 November 1977 ECIP Guidance through FY83 were extended through FY86 to include the construction period of all funded projects recommended by the study using the results of the Energy Price Forecasts summarized in VI.A above.

- A table of the resulting Yearly Incremental Escalation Rates based on these results can be found in Appendix F-12 in Volume III.
- A table of Escalation Factors for Extending Costs and Benefits based on those incremental escalation rates can be found in Appendix F-12.

H. Forms

- A form summarizing all project information and manipulating it into the form required by ECIP, and instructions for its use, can be found in Appendix F-14 in Volume III.
- A corrected ECIP Economic Analysis Form and instructions for its use can be found in Appendix F-15 in Volume III.
- A form to calculate the Life Cycle Cost of a funded project and instructions for its use can be found in Appendix F-16 in Volume III.
- Instructions for completing DD 1391 forms as envisioned for this program can be found in Appendix G-1 in Volume III.